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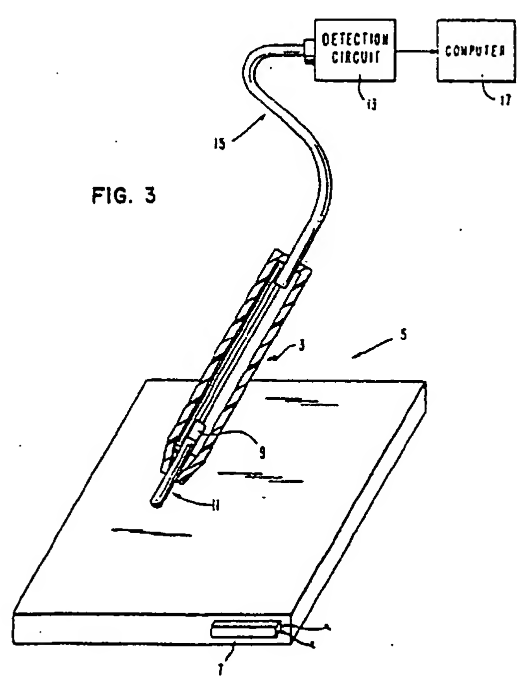
(54) Contact sensor for computer input stylus device.

(57) An acoustic contact sensor for handwritten computer input is disclosed. The contact sensor comprises ultrasonic sending transducer means (7) coupled to a writing surface (5) or display screen, receiving transducer means (9, 11) provided with the stylus (3), and circuit means (13) for providing a logic signal to a computer (17) when contact is made, in particular when the acoustic signal transferred along the writing surface and received in the stylus exceeds a given threshold. In an alternative embodiment, an ultrasonic sender is provided in the stylus, with the acoustic receiver being connected to the writing surface or display screen.

FIG. 3



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CONTACT SENSOR FOR COMPUTER INPUT STYLUS DEVICE

This invention relates to stylus input devices for computer data. More particularly, this invention relates to contact sensing means for such stylus devices.

There are many computer input devices which provide the location of a stylus in a working area. Examples of these devices are data tablets, light pens, and laser scanning devices etc. (For example, see U. S. Patents 3,134,099 and 4,564,928; Japanese Patents 55-39937 and 57-14978; and IBM Technical Disclosure Bulletin, Vol. 12, No. 3, August 1969, p. 390). These devices are frequently used to specify single points, for example, to define the ends of lines to be drawn in computer-aided design systems. However, although well suited for the above purposes, these devices are not suitable for handwritten input by use of the stylus.

Some of the principal requirements for acceptable handwritten computer input are a precision of 50-100 points per inch, a data rate exceeding 60 points per second, and a very sensitive mechanism to detect contact between the stylus and the working surface. The contact sensing feature is critical for segmenting the stream of coordinates into strokes typical of handwriting.

In most cases, location sensing techniques which provide adequate precision, detect the stylus at an ill-defined distance from the working surface. A common attempt for a solution to this problem is to add an electrical switch which can be activated by pressing the stylus against the working surface. However, reliable switches require considerable force and/or displacement, making it difficult to write in a natural manner. Conversely, devices with good contact properties, such as surface acoustic wave sensors, do not have adequate resolution and/or data rates. In some cases the contact sensor would be activated in error if the hand touched the writing surface.

It is therefore an object of the present invention to provide an extremely sensitive, high resolution, contact sensing device for handwritten computer input.

It is a further object that such contact sensing device be adaptable to different coordinate input facilities.

The invention described uses simple acoustic phenomena and techniques to provide an extremely sensitive contact sensing device which can be added to almost any coordinate input facility. The basic phenomenon exploited is the large difference in acoustic impedance between air and solids. Because of this difference, acoustic waves flowing between two solids can be almost completely blocked by an imperceptible air gap.

In one typical embodiment, a handwriting stylus is to be used with a writing tablet or surface. The contact sensing device comprises an ultrasonic sending transducer which is coupled to the writing surface and used as a source of acoustic waves. These waves may be bulk or surface waves. In conjunction with said writing surface, a stylus is equipped with a receiving transducer coupled to its tip to receive said transmitted acoustic waves and convert them to electrical signals. These signals from the stylus sensor are then fed to a detection circuit by a cable. The detection circuit provides logic signals to the computer whenever the acoustic signals exceed pre-determined threshold values.

In some cases, it may be desirable to avoid the connecting cable. This can be accomplished by equipping the stylus with a wireless link such as a battery operated FM transmitter. Still, another way to eliminate the stylus connecting wire is to reverse the functions of the transducers, using the stylus transducer as the source of ultrasonic waves for reception by a transducer coupled to the writing surface. In this case, a battery powered circuit in the stylus drives the transducer.

Embodiments of the invention are described in the following with reference to the drawings.

FIG. 1 is an isometric view of an embodiment of a display system according to the present invention wherein a light pen stylus is wired to its companion display.

FIG. 2 is a section view of the light pen stylus of FIG. 1 in the plane parallel to the pen's length.

FIG. 3 is an isometric view of a system according to the present invention wherein the coordinate system for locating the stylus is a light scanning system.

FIG. 4A is a block diagram of the frequency-sweep circuit for the writing surface of FIG. 3.

FIG. 4B is a block diagram of the receiver pick-up circuit for the pen stylus embodiment of FIG. 3.

FIG. 5 is a block diagram of a noise detection circuit for use with the embodiments of FIGS. 4A and 4B.

DETAILED DESCRIPTION OF THE INVENTION

A basic interactive computer display featuring a light pen or stylus is depicted in FIG. 1. As shown, the system includes a light pen (stylus) 1, a computer system 2, and display means 4 having a screen 6. Light pen 1 is connected to the computer

system 2 by means of a cable 8.

Referring now to FIG. 2, light pen 1 is seen to include a generally cylindrical body 10 suitable to be hand held and having the general shape of a stylus or pencil. Body 10 has a front end 12 in which a principal fiber element or conduit 14 is provided. Conduit 14 is axially mounted in body 10 and maintained in a fixed relation to body 10. Conduit 14 as shown is optically coupled at conduit end 16 to a detector 18 located at end 20 of body 10.

As will be apparent to those skilled in the art, detector 18 could also be located in computer 2 with appropriate optical coupling made by way of cable 8 without changing the scope and content of the subject invention. It should be appreciated that detector 18 can be any of a number of light detectors for correlating collected light with the raster sweep. In the most general case detector 18 comprises a transducer for receiving light from conduit 14 which then converts the light received into an electrical signal having an amplitude proportional to the light intensity.

Continuing with FIG. 2, the light pen further includes a contact sensor (screen sensor) 22 that provides an indication to the computer system 2 when light pen 1 has been placed in engagement with display screen 6. The screen sensor features acoustic means which is independent of the conduit 14 so that determination of screen engagement can be made independently of pen coordinate determination.

The screen sensor 22 of the light pen or stylus includes, for an ultrasonic sending transducer (not shown), a receiving transducer 26. The optical screen (or a writing tablet) acts as an acoustic conduit that facilitates communication between the sending and receiving units.

In accordance with the embodiment of the contact sensor of FIGS. 1 and 2, sensor 22 is located at the tip of stylus 10 and positioned axially thereof. The sensor could be transparent to light to prevent interference with light signal to conduit 14. Alternatively, the contact sensor 22 could be opaque to light whereby with concentric lenses the incident light could be focussed onto conduit 14. As another option, the optical detection system 14, 16, 18 can be mounted adjacent to the tip and made conductive of acoustic energy. The receiving transducer 26 can then be mounted distal from the tip.

In operation, when stylus 10 is brought into contact with screen surface 6, transmitted waves from the sending transducer, located at the screen periphery (not shown), are detected by receiving transducer 26 in the stylus. The receiving transducer 26 receives these waves and converts them into an electrical signal. This signal from transducer 26 is fed by cable 8 to a detection circuit located in computer 2. This circuit provides a logic signal to the computer 2 whenever the acoustic signal exceeds a pre-determined threshold value.

In the above modes of operation, reflected waves from the edges of the display screen or writing surface can combine with the transmitted wave to form a standing wave pattern. This will create one or more nodal regions of low amplitude where the stylus signal will be lost. Such standing waves may be suppressed by adding acoustic absorbers or scatterers to the edges of the writing surface. However, this may be expensive or impractical, for example if the surface is the faceplate of a display. As an alternative, short pulses can be used as the transmitted signal with sufficient delay between pulses to allow the reflections to damp out naturally. Another alternative involves repetitive sweeping of the transmitter frequency. This last technique works because the nodal positions depend on frequency. It is also possible to use the transmitter and receiver as a positive feedback oscillator to eliminate the effects of the nodal regions, the system breaking into oscillation at a frequency which may be different at different positions, automatically avoiding a frequency which would give a node.

In another embodiment, the fiber optic light pen stylus with raster position coordinate sensing means of FIG. 1 is replaced by a scanning laser system. As will be recognized by those skilled in the art, with such a scanning laser system, optical conduit 14 is replaced by a sweeping light source, such as a laser, and retroreflective bands are included on the stylus near its tip. Stylus coordinates can then be determined in the plane of the writing or display surface.

Referring now to Fig. 3, stylus 3 is in contact with writing surface 5. An ultrasonic sending transducer 7 is coupled to the surface and used as a source of acoustic waves. These may be bulk or surface waves. The stylus 3 is equipped with a receiving transducer 9 coupled to its tip 11 to receive these waves and convert them to an electrical signal. This signal from sensor 9 is fed to detection circuit 13 by cable 15. This circuit provides a logic signal to computer 17 whenever the acoustic signal exceeds a pre-determined threshold value.

FIG. 4A is a block diagram of a frequency-sweep circuit for the writing surface using the scanning laser system mentioned above. The circuit uses switched capacitor tracking filters in the receiver to automatically track the transmitter frequency. The transmitter consists of digital oscillator 32 operating at 100 times the desired ultrasonic frequencies. This frequency is divided by 100 by digital divider circuit 34 and amplified at 36 to drive

the ultrasonic transmitter 38. A low-frequency triangle wave generator 30 modulates the frequency of oscillator 32 to provide the frequency scan.

FIG. 4B is a block diagram of receiver or detector pick-up circuit for the pen stylus of FIG. 3. The signal picked-up by the stylus is amplified by pre-amplifier 40 and then fed to the switched-capacitor narrow-band filter 42. The output of oscillator 32 serves as the clock input to this filter, which is chosen to have a center frequency 100 times lower than the clock, or exactly equal to the ultrasonic signal. The output of the filter is rectified at 44, low-pass filtered at 46, and compared with a predetermined threshold at 48 to form the stylus contact signal for the computer.

Note that the frequency received by the stylus will differ from the instantaneous filter frequency because of the propagation delay along the surface. The effect of this is a lost of signal, which can be made small by proper choice of bandwidth, sweep rate and tablet size.

During writing, frictional noise between the stylus and writing surface will produce wide-band noise signals which may interfere with the detection circuitry, causing erratic loss of the contact signal. If the writing surface is fairly smooth, the problem may be eliminated with a low-friction writing tip such as Delrin (TM) or Teflon (TM) plastic. For rougher surfaces, the rubbing noise itself can be detected and used to sense contact. This can be accomplished by connecting the detection circuit of FIG. 5 to the output of pre-amplifier 40. Referring to FIG. 5, a wide-band amplifier 50 is connected to rectifier 52. This rectified signal is low-pass filtered at 54 and compared with a threshold at 56 to form the contact signal. The rubbing noise will be too small to detect at low writing speeds, wherefore, both circuits are needed. Their individual logic signals are connected to OR gate 58 to form a composite contact signal.

A similar arrangement to that of FIG. 1 is an embodiment wherein the connecting cable is not needed. This can be accomplished by equipping the stylus with a wireless link such as a battery operated FM transmitter.

Another way to eliminate the wire is to reverse the functions of the transducers, using the stylus transducer as the source of ultra sonic waves for reception by transducer. In this case a battery powered circuit in the stylus can drive the transducer. It will be appreciated that this method may be unusable if the writing surface, which is much larger than the stylus, is subject to high levels of acoustic noise.

A still further and different embodiment can be configured by eliminating the sending transducer.

In this mode, the stylus transducer is used as the resonant element of an electrical oscillator, for example a marginal oscillator of the type used to detect nuclear magnetic resonance. The circuit losses will increase abruptly when contact is made, leading to a measurable change in oscillation amplitude. A battery powered circuit can be contained within the stylus, and the contact signal can be sent to the computer, for example, by an IR or FM link.

Claims

1. Apparatus for sensing contact between a pen type stylus device for computer data input and a writing surface, characterized by:

a) ultrasonic sending transducer means (7) coupled to the writing surface (5) for projecting acoustic waves to said writing surface;

b) receiving transducer means (9) coupled to said stylus (3) for reception of said acoustic waves from said sending transducer means, and conversion of said acoustic waves to an electrical signal; and

c) circuit means (13) for providing a logic signal to the computer (17) whenever the acoustic signal exceeds a predetermined threshold value.

2. Apparatus for sensing contact between a pen type stylus device for computer data input and a writing surface, characterized by:

a) ultrasonic sending transducer means coupled to said stylus for projecting acoustic waves to the writing surface;

b) receiving transducer means coupled to the writing surface for reception of said acoustic waves from said sending transducer means, and conversion of said acoustic waves to an electrical signal; and

c) circuit means for providing a logic signal to the computer whenever the acoustic signal exceeds a predetermined threshold value.

3. An apparatus according to claim 1 or 2 wherein said stylus is linked to the computer device by a battery operated wireless transmitter.

4. An apparatus according to claim 1 or 2 wherein said ultrasonic sending transducer means transmits short pulses approximately 50 microseconds in length of duration with delays of approximately 500 microseconds in length between pulses.

5. An apparatus according to claim 1 or 2 wherein said writing surface has acoustic absorbers or scatterers located at the edges of said writing surface.

6. An apparatus according to claim 1 or 2 wherein said ultrasonic sending transducer means repetitively sweeps the frequency of said acoustic waves.

7. An apparatus according to claim 6 wherein said ultrasonic sending transducer means (7) comprises:

a) digital oscillator means (32) for operation at some multiple times the desired ultrasonic frequency;

b) divider means (34) for reducing the output of said digital oscillator means by the said multiplication factor;

c) amplifier means (36) for driving said transducer; and

d) low-frequency sweep generator means (30) for modulating the frequency of said digital oscillator means to provide a frequency sweep.

8. An apparatus according to claim 1 or 2 wherein said receiving transducer means (9) comprises:

a) pre-amplifier means (40) for amplifying the signal picked up by a receiving transducer;

b) switched capacitor tracking filter means (42) for tracking the transmitted frequency;

c) rectifier means (44) for rectifying the output of said tracking filter means;

d) low-pass filter means (46); and

e) comparator means (48) for comparing said received signal with a predetermined threshold signal.

9. An apparatus according to claim 8 wherein said receiving transducer means (9) further comprises:

a) second rectifier means (52) connected to the output of said pre-amplifier means (40);

b) second low-pass filter means (54) for filtering the output of said second rectifier means; and

c) second comparator means (56) for comparing the output of said second low-pass filter means to a predetermined threshold signal.

10. An apparatus according to claim 8 or 9 wherein the output of each of said respective comparator means (48, 56) is connected to an OR gate (58) to form a composite contact signal for the computer.

11. Apparatus for sensing contact between a pen type stylus device for computer data input and a writing surface, characterized by:
battery powered electrical oscillation circuit means for resonance of stylus transducer means such that upon contact of said stylus (3) to said writing surface (5) there is a change in the amplitude or frequency of the oscillation.

12. An apparatus according to claim 11 wherein a signal indicating a contact signal between said stylus and said writing surface is sent to the computer by a wireless link between said stylus and the computer in the infra-red frequency range.

FIG.1

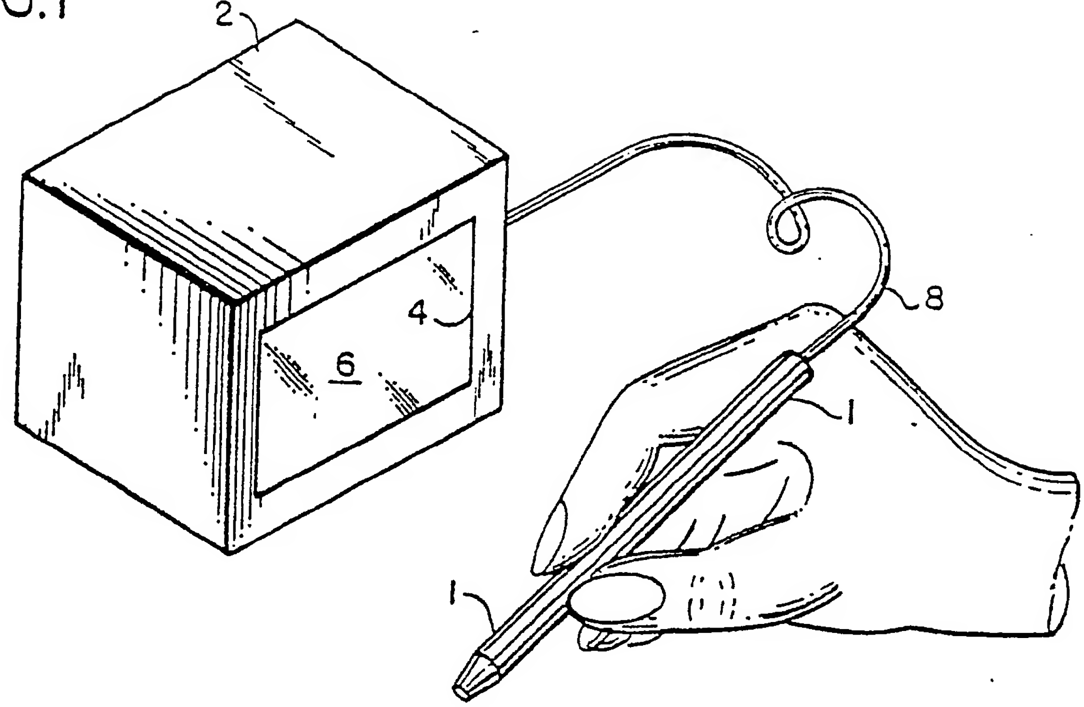
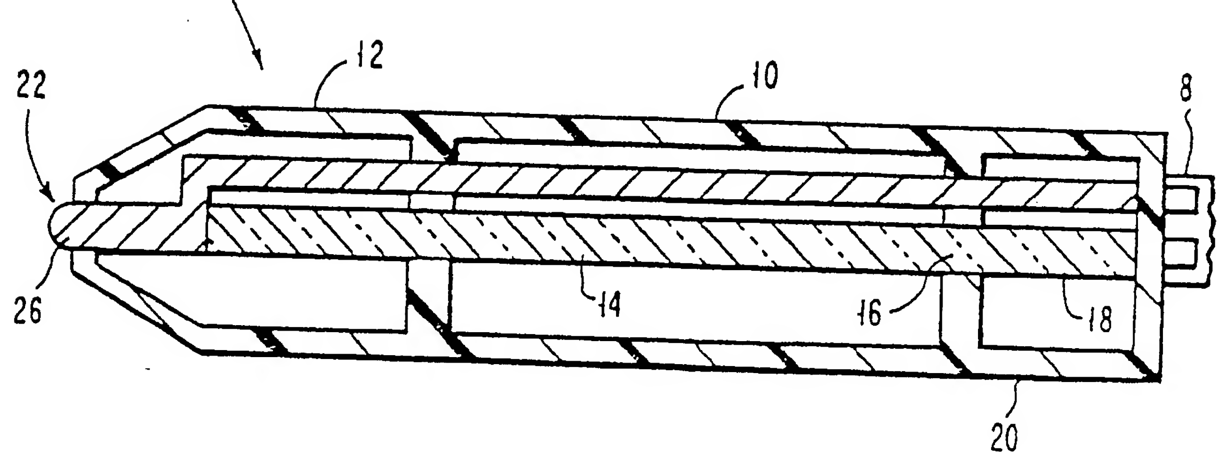


FIG. 2



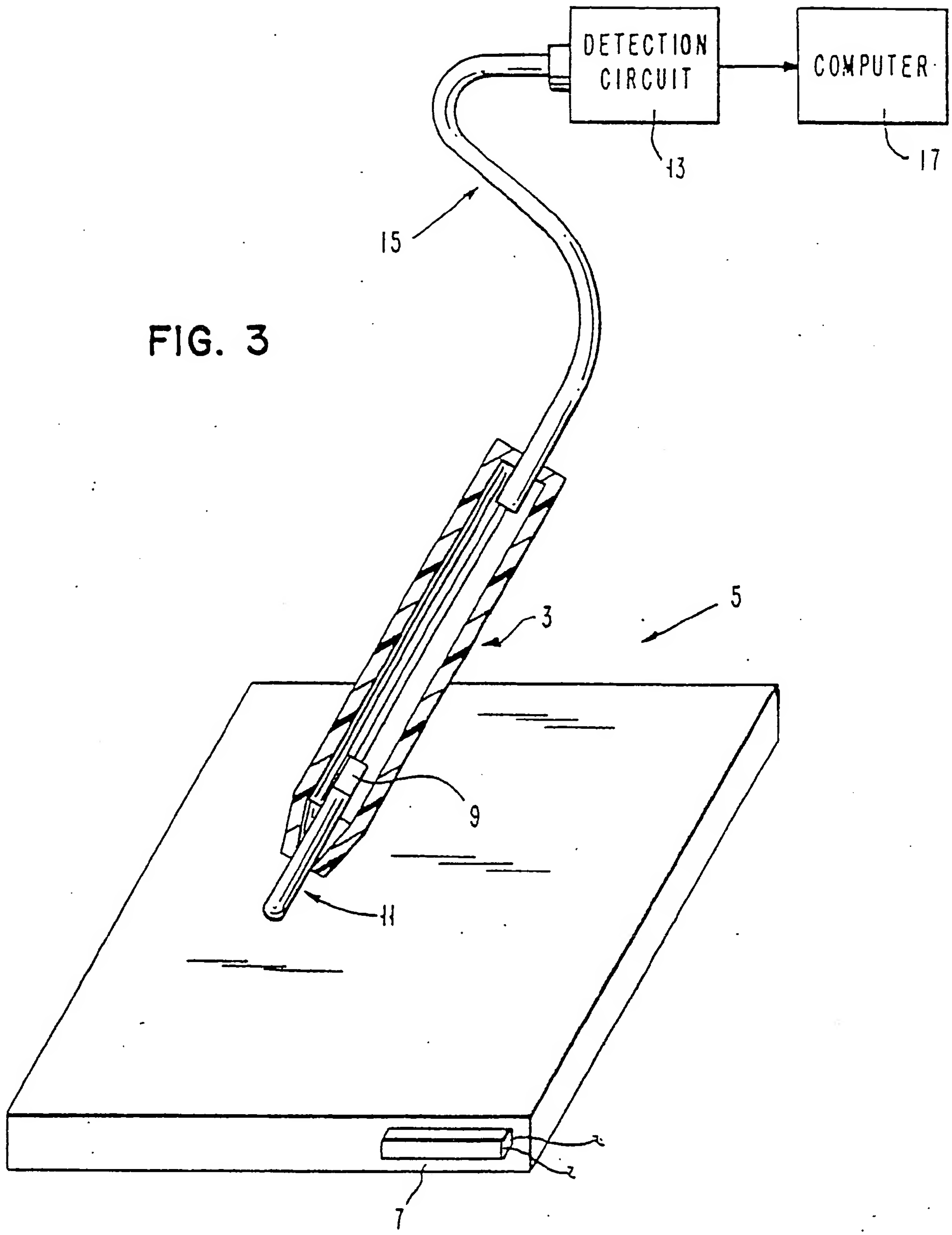


FIG. 3

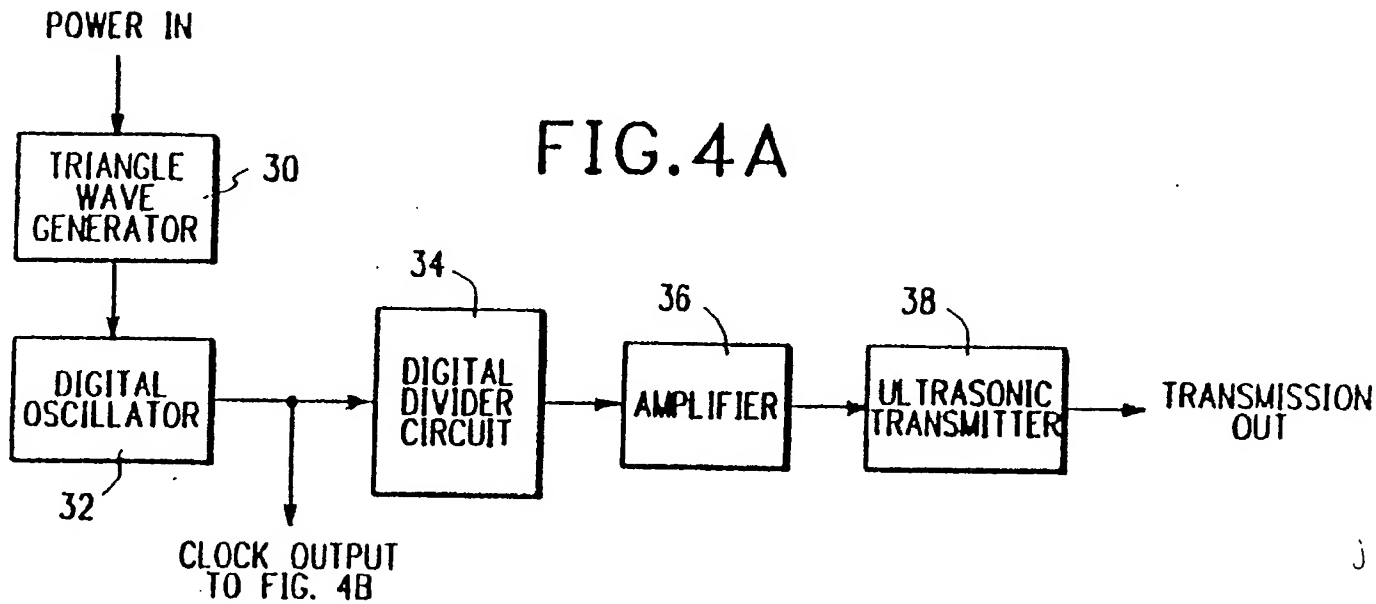

POWER IN
TRIANGLE WAVE GENERATOR
30
DIGITAL OSCILLATOR
32
CLOCK OUTPUT TO FIG. 4B
34
DIGITAL DIVIDER CIRCUIT
36
AMPLIFIER
38
ULTRASONIC TRANSMITTER
TRANSMISSION OUT

FIG.4A

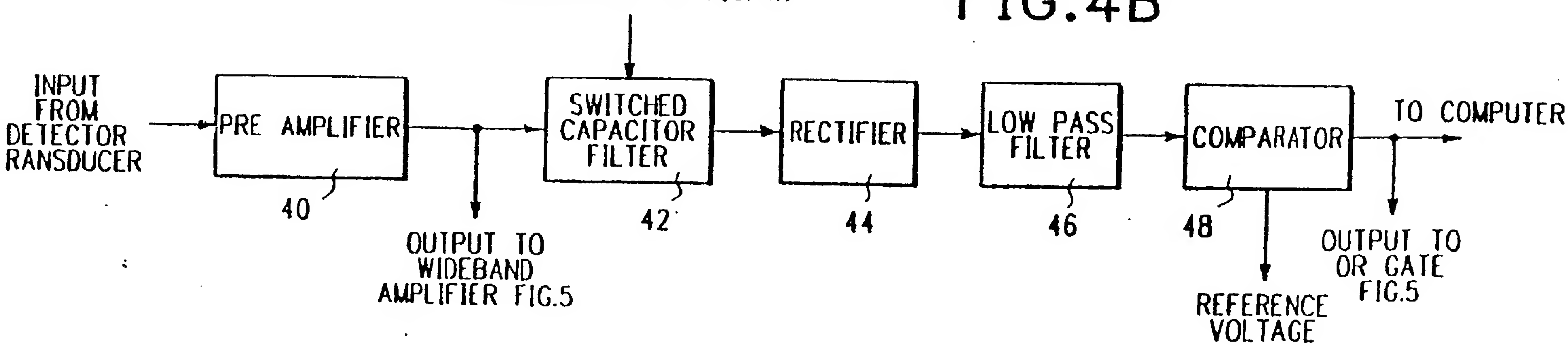

INPUT FROM DETECTOR RANSDUCER
PRE AMPLIFIER
40
OUTPUT TO WIDEBAND AMPLIFIER FIG.5
CLOCK INPUT FROM OSCILLATOR OF FIG. 4A
SWITCHED CAPACITOR FILTER
42
RECTIFIER
44
LOW PASS FILTER
46
COMPARATOR
48
REFERENCE VOLTAGE
TO COMPUTER
OUTPUT TO OR GATE FIG.5

FIG.4B

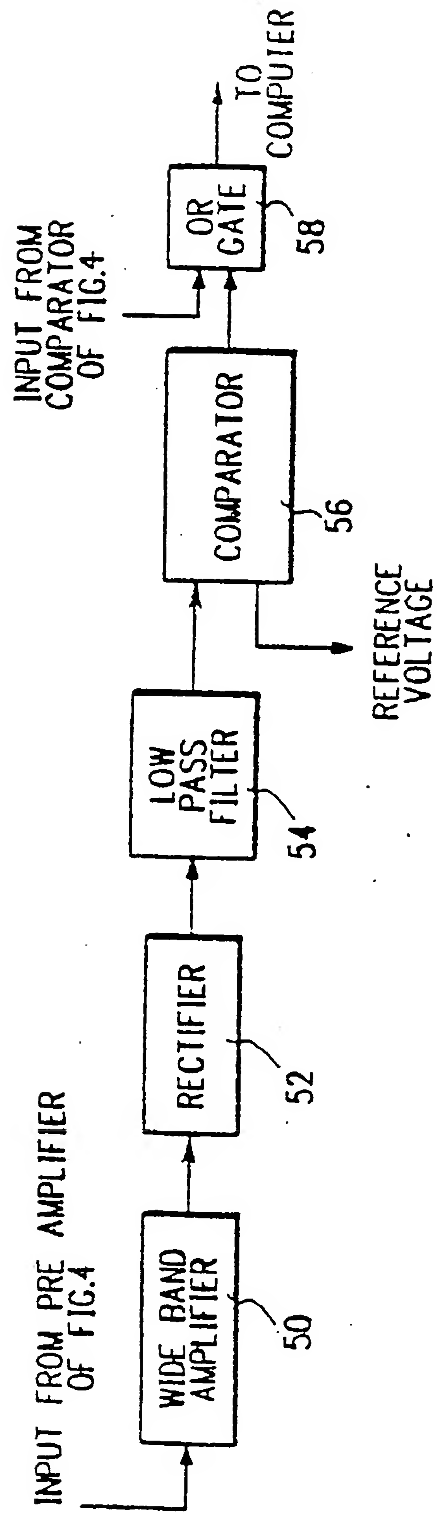

INPUT FROM PRE AMPLIFIER
OF FIG.4
WIDE BAND
AMPLIFIER
50
RECTIFIER
52
LOW
PASS
FILTER
54
COMPARATOR
56
REFERENCE
VOLTAGE
INPUT FROM
COMPARATOR
OF FIG.4
OR
GATE
58
TO
COMPUTER

FIG.5